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Countdown

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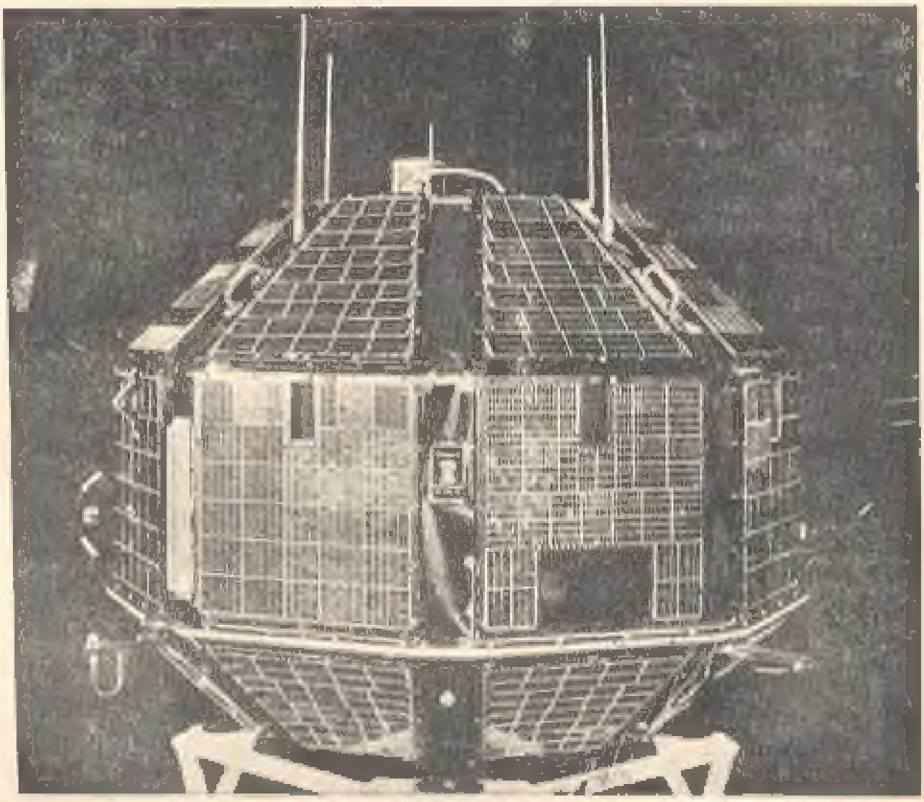
BHASKARA-II IN ORBIT



BHASKARA-II, India's second Satellite for Earth Observation, was launched successfully by an Intercosmos Rocket from a Soviet Cosmodrome on November 20, 1981 at 1400 hrs IST. Injected into a near-circular orbit at an altitude of about 525 km, with an inclination of 51°, the 436 kg satellite is circling the globe once every 95 minutes.

It may be recalled that BHASKARA-I launched in June 1979 completed its mission of carrying out remote sensing over India for a period of almost two years ending in May this year. Conceived essentially as a continuation of this remote sensing project, BHASKARA-II has the following specific objectives:

* Conduct earth observation experiments to collect, process, analyse and disseminate data of relevance to hydrology, forestry and geology using two television cameras operating in visible (0.6 micron) and near-infrared (0.8 micron) wave-lengths.

* Study ocean surface state using a three-frequency microwave radiometer system operating at the frequencies of 19 GHz, 22GHz and 31 GHz

* Evolve the methodology of collection and dissemination of data of meteorolo-

gical interest from remotely located platforms.

* Evaluate the performance characteristics of indigenously developed thermal paint and solar cells under prolonged exposure to space environment.

These objectives are sought to be accomplished through two categories of payloads, onboard the BHASKARA-II, called Primary and Secondary payloads. The Primary payloads are:

1. The TV Camera system designed to obtain imageries for deriving information of relevance to forestry, hydrology, geology and biomass. The system operates in two wavelength bands, one in the visible region (0.6 micron) and the other in the near infra-red region (0.8 micron). Each frame covers an area of 341km x 341 km with a typical resolution of about 1km. It may be mentioned that the very first pictures already taken by the camera system represent areas over the Arabian Sea and the adjoining region in the Western Ghats and Southern Karnataka.

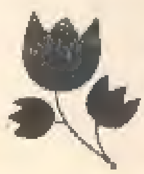
2. The Satellite Microwave Radiometer (SAMIR) is designed to sense the brightness temperatures of earth over the satellite track on the Indian Ocean and the surrounding areas. The data thus collected by SAMIR will be useful in determining the sea-state, the water vapour and liquid water content in the atmosphere over the sensed area.

The Secondary Payloads are concerned with (1) Thermal paint experiment in which the paints are supplied by VSSC, (2) Solar cell experiment in which the cells are supplied by Bhabha Atomic Research Centre, Bombay and the Solid State Physics Laboratory, New Delhi and (3) Data collection in which ISAC, Bangalore and SAC, Ahmedabad are collaborating with the India Meteorological Department.

The Ground Stations for receiving telemetry data from BHASKARA-II and for tracking and commanding the satellite are at SHAR Centre, Sriharikota, SAC at Ahmedabad and at Bearslake near Moscow, USSR. The equipment required for operating the ground stations were developed at the ISRO Centres and were installed and commissioned under the overall direction of ISTRAC/SHAR. The final processing and dissemination of the data among the users will be the responsibility of SAC, Ahmedabad.

As is typical of all major ISRO Projects, BHASKARA-II is the result of efforts by all ISRO Centres as well as by a number of other academic and research organisations. Examples of this latter category include Hindustan Aeronautical Limited, Bharat Electronics Limited, the Indian Institute of Science and various IITs. In addition to the launch support, the Academy of Sciences of the USSR provided some of the satellite subsystems like the solar panels, chemical batteries, tape recorders and the titanium gas bottles.

In a sense BASKARA-II is a watershed event in that it brings to a close the first phase of experimental systems while at the same time signalling the transition towards semi operational systems to come into being in the later part of this decade.



KNOW ABOUT GRAVITY AND WEIGHTLESSNESS

"One day in the year 1666 Newton had gone to the country, and seeing the fall of an apple, as his niece told me, let himself be led into a deep meditation on this cause which thus draws every object along a line whose extension would pass almost through the centre of the earth".

—VOLTAIRE

In spite of the authority of VOLTAIRE, the story is widely believed to be apocryphal. But our interest in this article is not history but the idea behind the story.

The Newtonian view is that things fall because earth attracts all objects towards itself. This attraction is commonly known as the gravitational attraction. The "Universal Law" of gravitation asserts that all matter is endowed with this 'mysterious power' of attracting all other matter. Actually, the gravitational interaction represents an action-reaction pair. Thus if a marble is attracted by the earth, surely the marble is attracting the earth with exactly the same force. One may be tempted to ask: Why does not the earth "fall" towards the marble? The answer is again given by Newton: A force acting on a body causes that body to accelerate in inverse proportion to its mass. Thus, if the marble falls towards the earth with say an acceleration of about 10 metres/sec./sec. then the acceleration of the earth 'toward' the marble is

$$\left\{\frac{10X \text{ mass of marble}}{\text{mass of earth}}\right\}$$

Now what is the mass of the earth? It is about 6000000000000000000000000 kg! When such a huge number appears in the denominator, the value of that acceleration is, for all practical purposes, zero! Thus, our mother earth does not budge even an iota!

The statement of VOLTAIRE suggests that the line along which the apple falls toward the earth would, if extended, pass through the centre of the earth.

Recall that in an earlier issue of Countdown we mentioned how the plane of the orbit of a satellite necessarily passes through the centre of the earth. This is simply because the laws which govern the motion of 'falling' bodies hold good for satellites; indeed, they are valid for all planetary motions and even beyond the solar system. Indeed, this achievement of Newton (and Galileo) is considered to be the first of the three great syntheses in science. (Incidentally, the other two are in the fields of electromagnetism and relativity).
When combined with the three famous laws of motion of Newton, the law of gravitation becomes so powerful that it explains a staggering range of natural phenomena amon which we may count: the behaviour of projectiles near the ground, planetary and satellite motions, the phenomenon of tides, the bulging of earth at the equator, the continuous motion fluids and so on. Indeed, the success of the Newtonian mechanics seemed so universal and complete that it gradually gave rise to what is known as "the mechanistic view of the universe' — a view point that almost became a dogma. (See Box: Laplace, Nepolean & God).

But we are digressing; let us see how this mechanistic view helps us to understand some of the very basic concepts in Space Technology.

First, the concept of force. Prior to Newton and Galileo people thought that whenever an object was moving, a 'force' was acting

LAPLACE, NAPOLEON & GOD

PIERRE SIMON LAPLACE (1749-1827), the great French mathematician was a champion of the mechanistic view of the universe that arose out of the Newtonian framework. So absolute was LAPLACE's confidence in the infallibility of the Newtonian mechanics that he was reported to have remarked: "An intellect which at a given instant knew all the forces acting in nature, and the position of all things of which the world consists—supposing the said intellect were vast enough to subject the data to analysis—would embrace in the same formula the motions of the greatest bodies in the universe and those of the slightest atoms; nothing would be uncertain for it, and the future, like the past would be present to its eye".

LAPLACE himself undertook this enormous task of perfecting NEWTON's theoretical framework and of applying it to a truly vast range of natural phenomena. The result was a Magnum Opus called Macanique Celeste in which LAPLACE succeeded in explaining the motions of all the planets, moons and even of comets. In addition, his five-volume tome dealt with other phenomena related to gravity like, tides, the changes in atmospheric parameters with height, etc. in great detail.

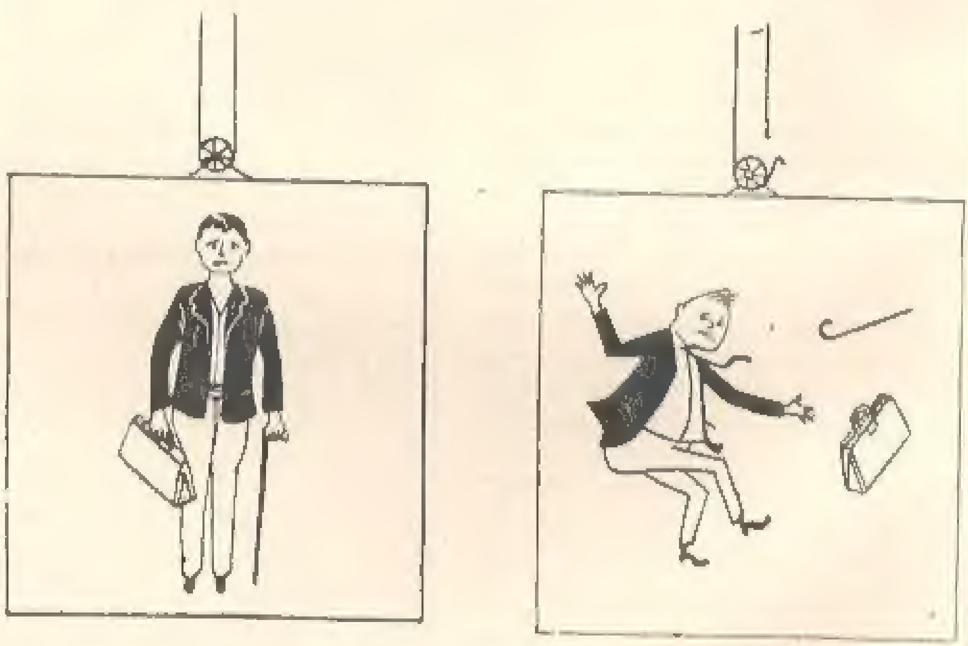
There is a story which says that when LAPLACE presented the first edition of his work to NAPOLEON BONAPARTE, the emperor remarked: "Monsieur LAPLACE, they tell me that you have written this large book on the system of the universe and have never even mentioned its Creator". To this LAPLACE replied candidly: "I had no need for that hypothesis".

on it - an idea that seems fairly obvious. But the Newtonian view modified that concept. It says that when a body is moving in a straight line with constant speed (i. e. uniform velocity) the net force acting on it is zero! In fact, Newton treats a body moving with uniform velocity on par with a body at rest (in a given frame) in the sense that in both the cases there is no force acting. This property of matter is called 'inertia'. The reverse is also true; whenever a body is changing its speed or direction or both, there must be a force acting. Let us consider the example of a satellite going around the earth once every 100 minutes in a circular orbit. If we ignore things like the resistance due to air etc, this period remains fairly constant. This means the speed of the satellite is constant. Yet there must be a force acting on the satellite because it is moving in a circle and not in a straight line. What is this force? It is none other than the gravitational attraction of the earth. So it is absolutely wrong to say that an orbiting satellite is beyond the earth's gravitational pull. It goes round the earth precisely because of the earth's gravity.

To be more general, we may say that to make a body deviate from a straight line path, a force needs to be applied which is given a special name: Centripetal force (meaning centre seeking force). In other words the earth's gravity provides the centripetal force for the orbiting satellite. It is worth repeating that in a uniform circular motion, the velocity is changing continuously even though the speed is constant (because the direction is continuously changing).

There is another wrong concept which is widely prevalent among many: viz., the concept of weightlessness. People seem to think that in orbiting satellites astronauts feel weightless because the centripetal force (i. e. earth's gravitational pull) is balanced by what they call the 'centrifugal' force acting on the satellite (or the astronaut) in the opposite direction. If the earth's gravitational pull were to be really balanced by the so-called centrifugal force, it would mean that the net force acting on the satellite is zero. If so, according to Newton's laws, the satellite should be either at rest or should move in a straight path But we all know that the satellite is doing neither; it is moving in a circular (or an elliptical) orbit. Thus the concept of "balance" is wrong.

Besides, the so-called 'centrifugal force' is not real; it is fictitious and is at best called a psuedo-force. This is because it does not originate in any tangible matter. (Contrast this with the gravitational force which originates in matter or electrical forces which originate in electrical charges). How can an unreal or a psuedo force balance a 'real' force? Actually the 'forces' we seem to experience whenever a bus or a car we are travelling in takes a sharp turn are due to 'intertial' effects and are not due to the hypothetical 'centrifugal' forces. These inertial effects can easily and convincingly be described but this article is not the proper place to give an account of them. In short, the sooner one gets rid-off this centrifugal hang-up, the better he would be!



The man in the lift: The picture on the left shows a man standing inside a stationary lift holding his bag and the umbrella. The rope holding the lift is taut because it is preventing the lift from falling; the man is erect because the lift-floor is supporting his weight through the reaction acting upwards; his arm holding the folio is also straight because he is preventing the bag from falling. In other words, all are restrained from responding fullyto gravity.

In the picture on the right the rope supporting the lift is cut-off; the rope becomes limp and the lift, the man and his possessions are all now falling freely—all with the same acceleration and velocity. They are all now 'weightless', each moving independent of the other. 'Freefall' or unrestrined motion in a gravitational field is what causes "weightlessness". This is what happens inside an orbiting satellite which is actually responding fully to the gravity of the earth.

Let us consider the 'weightlessness' in some detail. To start with, when and how do we feel this force called 'weight?' When we stand on the floor of a room, we feel our own weight because we are prevented from responding freely to gravity by the floor. Suppose the floor we are standing on suddenly gives way. Suddenly the 'weight' disappears (of course, the consequences may be disastrous !). In simple terms then weightlessness results when no resistance is offered to gravity. Indeed a good definition for weightlessness is: Unrestricted motion in a gravitational field (or free fall) is synonymous with weightlessness. (See illustration of the 'Man in the Lift').

Some times the condition of weightlessness is described as 'zero-g' condition. This is an unfortunate misnomer because it might have been responsible for the wrong notion entertained by many people that an orbiting satellite is operating in "gravity free" space.

It must be pointed out that weightlessness inside orbiting satellites is important not only in the context of manned flights but in the design and development of any piece of hardware intended to do mechanical operations while in orbit. An example is the solar panel deployment mechanism used on-board the APPLE - the first experimental communication satellite of our country. Readers of Countdown may recall that this system designed and developed by our Centre, consisted of a metallic yoke to support the solar panel, hold down, release and locking mechanisms, cable cutters and explosive bolts. Since the system had to operate only after the APPLE was in orbit, it was designed to work in the weightlessness environment. Because of this, a very light structure for the yoke was adequate (thus achieving, in principle, an advantage in payload weight for launch). The deployment itself had to be reasonably slow to minimize disturbances to the craft and to avoid any possible mechanical damage to the light-weight structure. But how was this weight lessness simulated ? Ofcourse, one obvious method was to drop the whole thing from some height thus letting it experience freefall. This procedure, though theoretically perfect, would have ruined the deployment mechanism beyond repair ! What was actually done can be understood from the following analogy. Suppose we hold a long and reasonably massive pole at one end and lift. Naturally because of its own weight, it will bend a little with the free end drooping down a bit. In other words, it will sag. This condition of the pole is described in technical language as being due to 'bending' moments'. But if we were to 'lift' the pole in a weightlessness environment, it would not bend at all, i. e. the bending moments will be absent. During the weightlessness simulation tests on the solar panel deployment mechanism the 'berding moments' were similarly avoided.

There are many beneficial things accruing to us from this weightlessness. For example, one can make perfectly spherical ball-bearings under weightlessness condition — a thing that cannot be achieved on the earth. There are many such applications of weightlessness which have given rise to new 'space-processing' techniques.

Before concluding, we must make at leact a cursory reference to the theory of General Relativity which has replaced the Newtonian theory of gravitation. While it is evidently beyond the scope of this article to include a popular description of EINSTEIN'S theory, one elementary aspect of it can be understood from what we have said above. Remember, that the orbit in space around the earth of a satellite is independent of its mass, shape, chemical composition and so on (we are ignoring things like atmospheric drag and other perturbations). It depends only on the initial conditions of injection, viz, injection angle and injection speed. Thus a milligram of a sand particle and a 100 tonne spacecraft made of steel, follow the same orbit, if injection parameters are identical. Thus one might be tempted to ask : on what does the orbit depend ? The answer one gets from General Relativity is simipe and elegant : on the properties of space itself ! It turns out that the very presence of matter modifies the properties of space around it; this modification being greater for more massive chunks of matter (Technically, the modification is said to result in a change of "curvature" of space). It is as though the matter – space interaction results in a "groove" in space that defines the orbit for the satellite (technically called the geodesic.) Thus the old Newtonian concept of interaction between pieces of matter through gravitational forces is replaced, in General Relativity, by the essentially geometric concept of 'curvature of space'. It is also fairly evident why gravity is universal; after all, it is a property associated with space-time which is certainly 'omnipresent'.

In conclusion we may just mention that modern cosmological theories based on General Relativity attempt to explain a staggering range of phenomena including the 'life-stories' of such esoteric 'objects' like black-holes, white dwarfs, red giants and so on. Indeed they deal with the very fabric of this universe, including its creation ! EINSTEIN once said: "The most incomprehensible thing about nature is that it is comprehensible" !

GETTING AHEAD WITH SLV-3 AND ASLV

We are all aware that we have had so far 3 flights of the SLV-3 and also that two of them carried the Rohini satellite. The immediate future course of the SLV-3 Continuation Project has now been defined.

The next flight is designated SLV-3-D2 and it is slated for launch before mid—September 1982. This vehicle will include certain changes aimed at achieving ease of integration and higher reliability. One important modification is the elimination of the four tiny rockets used in the second stage for controlling the orientation during the unpowered flight. This reduces the number of parts in the control systems leading to better reliability. SLV-3-D2 also envisages to use for its fourth stage rocket motor a material known as Kevlar. Nevertheless, D2 will also have the flexibility to accept the earlier motor with fiberglass case, in the event of any change of plans.

Now, what is atop SLV-3-D2 ? A Rohini Satellite; weighing 42 kg this time. This satellite, carrying an improved version of a Landmarker Camera, will be in orbit at least for one hundred days.

Parallelly, the work toward SLV-3-D3 will also be started. Details such as the launch date and the satellite will be finalised in due course.

ASLV is, in simple terms, the SLV-3 launch vehicle whose first stage is aided by two rocket motors strapped on to it. These strap-on motors have the same propulsion capabilities as the first stage of the 'core' vehicle. This augmentation of thrust results in a satellite weighing 150 kg contrasted to 40 kg of the core vehicle. The satellite will be injected into an orbit within the error bounds of $\pm$ 30 km in altitude and $\pm$ 0.5° in inclination.

One important task of ASLV besides, of course, launching the 150 kg satellite, is to demonstrate the major technologies required subsequently for PSLV. Some examples for these new things are strap-on techniques, closed loop guidance, on-board computer and yaw maneuver. Altogether, three flightworthy ASLV vehicles are planned now; out of these, one is a stand-by. Closed loop guidance, crucial to PSLV because of stringent accuracy of the orbit, will be tried out at least in the second ASLV flight, if not in the first .

SPACE IN TRADE FAIR

The Space pavilion proved a great attraction at the India International Trade Fair inaugurated on November 15, 1981 by Shri Hidayatulla, Vice- President of India. It was grouped along with certain others under the broad category' Science and Technology'. The 700 square meter pavilion included a 'Hall of Rockets' and a 'Hall of Satellites'. The true size model of SLV-3 stood majestically outdoors, dwarfing everything else. Models of Viking Liduid Engine and RH-560 sounding rocket had also their place in the open.

Inside, there were the scaled down working models of SLV-3 APPLE and NRSA Earth Station, true size models of APPLE, RS-1 and Bhaskara and also the scaled-down models of facilities like SPROB and STEX. The walls of the pavilion were lined with splendid photographs, colour and black & white, depicting the gamut of ISRO activities. The video shows put a finishing touch to this magnificent panorama of Indian space program organised by the Public Relations Unit of ISRO Headquarters. Preparations are under way for presentations at London, New York and Vienna during 1982.

News & Events

After the successful acceptance tests, the CYBER was formally inaugurated on November 5, 1981 by Prof. M. G. K. MENON, Secretary, Department of Science and Technology. The computer is now open to users.

VSSC HOSTS NATIONAL SYMPOSIUM ON THERMAL ANALYSIS

Jointly sponsored by the Indian Thermal Analysis Society and VSSC, the third National Symposium on Thermal Analysis was held at our Centre during the period 23-25 November, 1981.

Inaugurated by the Director, VSSC, the symposium was attended by over 120 delegates from different research and academic organisations like BARC, (Bombay), IISc, (Bangalore), various IITs and so on. During the deliberations over 74 research papers were presented and discussed.

The picture shows Shri M. R. KURUP, Director, PCM Group welcoming the delegates.

Countdown wishes you all a happy 1982

JANUARY

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The following holidays will be observed in VSSC during 1982 :

1	Republic Day	January 26
2	Mahavira Jayanti	April 6
3	Good Friday	April 9
4	Budha Purnima	May 7
5	* Id-ul-Fitr	July 23
6	Independence Day	August 15
7	First Onam	August 31
8	Thiru Onam	September 1
9	Sree Narayana Guru Jayanthi	September 3
10	Mahanavami	September 26
11	* Idu'z Zuha (Bakrid)	September 28
12	Mahatma Gandhi's Birthday	October 2
13	Deepavali	October 16
14	Muharam	October 29
15	Guru Nanak's Birthday	November 1
16	Christmas	December 25

* Subject to change depending on the appearance of Moon

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